Our Carbon Footprint

In March 2005, Mayor Nickels challenged the community and made a commitment for Seattle's citywide emissions to meet the Kyoto target—reduce greenhouse gas emissions to seven percent below 1990 levels by 2012. He appointed the Green Ribbon Commission (GRC) to develop recommendations to meet the target. One of the Commission's first tasks was to understand the sources and trends of emissions in Seattle.

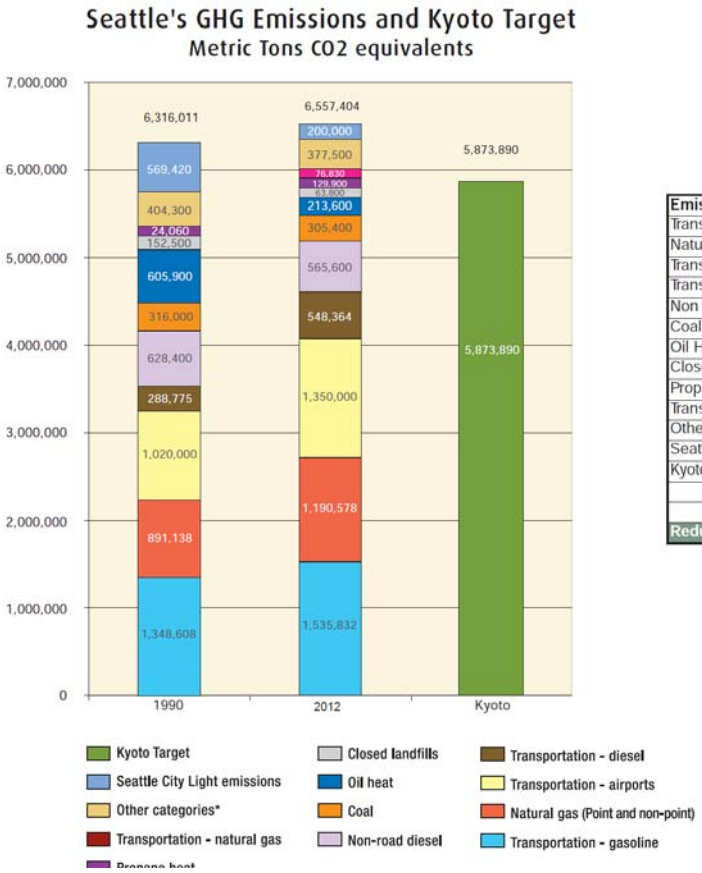
The GRC's Report and Recommendation include an inventory of Seattle's greenhouse gas emissions for both the baseline year, 1990, the target year, 2012 (Attachment A). It was developed based on the inventory of greenhouse gas emissions that was completed in 2002 for both City government operations and for the geographic area within City limits (Attachment B).

However, during the course of its work, the GRC made several important updates and improvements to the 2002 citywide inventory by using more recent and more accurate data (Attachment C). Those changes strengthen the baseline analysis and **make the 2002 inventory out of date.** Specifically, these changes are:

- **City Light emissions:** Emissions associated with Seattle City Light operations were not included in the 2002 citywide inventory because the bulk of them occurred outside the geographic boundaries of the inventory, i.e., city limits. However, the GRC decided to include all emissions associated with Seattle City Light operations in the updated inventory both because the City has direct control over those emissions and because nearly all of City Light's energy is consumed within Seattle. Thus, City Light's emissions were added to both the baseline year, 1990, and to the target year, 2012.
- **Natural gas emissions:** The GRC Report and Recommendations include data specific to Seattle's residential and commercial natural gas customers for the baseline and target years that were obtained in 2005 from Puget Sound Energy, the gas utility; the data are more current and accurate than those used in the 2002 inventory. The 2002 inventory numbers were produced in 1999 and, rather than being based on actual billing records for Seattle customers, they were based on data provided by the two gas utilities in existence at the time and were for countywide gas use—which then had to be extrapolated to represent Seattle natural gas use.
- **Gasoline and on-road diesel emissions:** The 2002 inventory based emissions for gasoline and on-road diesel use on countywide fuel sales data provided by Puget Sound Clean Air Agency and then, using population data, extrapolated the data to be "Seattle specific." Since fuel sales specific to Seattle are not available, for the GRC process, vehicle miles traveled (VMT) were used to estimate emissions. The VMT are measured by the Puget Sound Regional Council and are based on actual on-road measurements inside Seattle City limits.

With these changes incorporated, the GRC concluded that the revised inventory presented a more accurate picture of Seattle's emissions than the 2002 version and decided to use it as the basis for its Report and Recommendations (see Attachment C). It's also important to note that one of the GRC recommendations is that the City completely updates the emissions inventory on regular three year cycles, starting in 2006 with 2005 data.

Attachment A



Emissions source	1990	2012	
Transportation – gasoline	1,348,608	1,535,832	
Natural gas (Point and non-point)	891,138	1,190,578	
Transportation - airports	1,020,000	1,350,000	
Transportation - diesel	288,775	548,364	
Non - road diesel	628,400	565,600	
Coal	316,000	305,400	
Oil Heat	605,900	213,600	
Closed landfills	152,500	63,800	
Propane heat	66,910	129,900	
Transportation – natural gas	24,060	76,830	
Other categories *	404,300	377,500	
Seattle City Light emissions	569,420	200,000	
Kyoto Target			5,873,890
Total:	6,316,011	6,557,404	
Reductions needed:			683,514

Counting Kyoto: Our Target for Reducing Seattle's Climate Pollution

The Kyoto Protocol target is to reduce global warming pollution—measured in emissions of carbon dioxide and other "greenhouse gases" that are causing climate disruption—to seven percent below 1990 levels by 2012. To meet this target in Seattle, we estimate that the community must reduce its greenhouse gas emissions by about 683,000 metric tons—the equivalent of taking about 148,000 cars off the roads.

Where does this number come from? Any serious initiative to reduce global warming pollution must begin with a very challenging first step: A greenhouse gas emissions inventory that establishes the baseline against which progress will be measured, and identifies the major sources of pollution that will be the focus of the program. Seattle's inventory of greenhouse gas emissions is indicated in Figure 1. The inventory shows that the global warming pollution in our community—expressed as "carbon dioxide equivalents," the main pollutant—comes primarily from the use of fossil fuels such as gasoline, diesel and natural gas. More than 36 percent comes from gasoline-, diesel- and natural gas- powered motor vehicles, and another eight percent or so is from "non road" diesel-powered vehicles such as ships and construction equipment. About 18 percent comes from natural gas used to heat homes and businesses, and another 20 percent comes from emissions at local airports.

In 1990, Seattle emitted about 6,316,000 metric tons of global warming gases. Our Kyoto target—seven percent below 1990 emissions—is 5,874,000 metric tons.

Meeting the Challenge

The Kyoto Protocol is a framework for international action on climate protection. Applying this framework to a local community is a challenging task, in large part because greenhouse gas emissions – like most other forms of pollution – do not adhere to geographic boundaries or local government jurisdictions. For example, Seattle's electricity is produced outside of the city, so the few emissions associated with that production occur elsewhere. Similarly, cars commuting into and out of Seattle, or traveling through Seattle on interstate highways, produce air and global warming pollution here, even if they are not being fueled in Seattle or owned and driven by a Seattleite. So, where do we draw the lines?

Unfortunately, there is no standard protocol for making these types of decisions and creating a greenhouse gas emissions inventory for a local community. There are standard protocols for both countries and companies; but creating a local inventory, and calculating a local global warming pollution baseline and reduction target, requires a great deal of professional judgment.

A Sound Approach

Though challenging, we are confident in our approach to establishing the baseline and the target for Seattle's climate protection initiative. To begin, we created a Metrics Sub-Committee consisting of several Green Ribbon Commission members to carefully review the best available data, and, using their best professional judgment, to make decisions. In addition, we consulted with the people and organizations in our community who have the most expertise and experience in creating greenhouse gas emission inventories.

Key decisions that are embedded in the inventory and shown in Figure 1 include the following:

- We used up-to-date information on actual and projected natural gas consumption in Seattle, provided by Puget Sound Energy.
- We obtained current data on vehicle miles traveled in Seattle, provided by the Puget Sound Regional Council. We translated that information into estimated emissions by using U.S. Department of Energy data on vehicle fuel efficiencies and, using best professional judgment, estimated average fleet fuel efficiencies for 2012.
- We included all Seattle City Light emissions resulting from serving retail load because, even though most of City Light's operations are outside of the city, almost all of the electricity they produce is consumed within the city.
- Although it is located outside of the city, we included about 30 percent of the total estimated emissions from Sea-Tac International Airport, based on the percentage of total air travel by Seattle residents and businesses.

It is also important to stress the importance of recycling as a climate protection action. The more products that can be reused or recycled, the less energy used for manufacturing and the less waste that needs to be transported and landfilled. However, counting the energy used to produce products and the benefits of recycling were beyond our capabilities for this report.

(To access the full report, please visit www.seattle.gov/climate)

Attachment B

Inventory and Report: Seattle's Greenhouse Gas Emissions

City of Seattle

Office of Sustainability and Environment
September 2002

Contacts:
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City of Seattle Greenhouse Gas Inventory

INTRODUCTION

Global warming is occurring as a result of dramatically increased concentrations of atmospheric greenhouse gases, primarily carbon dioxide. While natural processes such as plant respiration and organic decomposition also release these gases, fossil fuel burning and other human activities have accelerated the accumulation of the gases to a level that exceeds the earth's capacity to absorb them as part of the natural cycle. The heat trapped by the greenhouse gases is raising average global temperatures to unprecedented levels – 1998 and 2001 are the warmest years on record.

Scientists project that, due to rising temperatures, the Pacific Northwest can expect higher temperatures, wetter winters, drier summers, reduced river flows, increased coastal flooding and erosion and decreased forest health and productivity. Snowpack – the region's natural storage system for water supply and hydroelectricity - is likely to decline by half by 2050. Responding to global climate change has been a City priority since the early 1990's.

In July 2001, via Resolution 30316, the Seattle Mayor and Council directed the City's Office of Sustainability and Environment (OSE) to:

- conduct an inventory of the City's greenhouse gas emissions (GHG) for 1990 and 2000;
- identify any existing programs that would have reduced Seattle's GHG emissions since 1990;
- project Seattle's GHG emissions in 2010;
- following completion of the inventory, prepare plans that would reduce Seattle's GHG emissions from seven to forty percent below 1990 levels.

OSE relied on the technical assistance of an Advisory Group[1] to help define the scope and boundaries of the inventory project and to resolve technical issues. With the input of the Advisory Group, several parameters for the project were agreed to:

- The primary purpose of the GHG inventory is to provide baseline data to inform City decision making, i.e., evaluate existing emission reduction programs and plan for further reductions.
- To the degree possible, the inventory will be compatible with standards that may be applied nationally or internationally in the future. Thus, for example, the Intergovernmental Panel on Climate Change (IPCC) 1996 national inventory guidelines were used for calculating quantities of emissions for each fuel type (e.g., coal, diesel, etc.). The World Resources Institute "GHG Protocol" provided a model for including emissions from purchased energy and indirect emissions sources.
- To be credible, the inventory and data base would be[2]:
  - Transparent, clearly documenting and explaining decisions on assumptions, sources of data, etc.
  - Complete, accounting for all relevant and material GHG emissions and activities within the boundaries selected for the inventory[3];
  - Accurate in accounting to provide assurance on the integrity of the data;
  - Consistent, allowing meaningful comparisons of emissions data over time.

The inventory is intended to focus on emissions that are related both to the City's internal activities as a municipal government and to the emissions in the larger community that may be influenced by City policies and programs. To capture both of these sets of data, this document includes both a *City and Utility Operations GHG Inventory* and a *City Wide GHG Inventory*. Neither of these inventories provides

[1] The Advisory Group was lead by OSE and included representatives from Seattle City Light, Seattle Public Utilities, the Mayor's Office, City Council Central Staff, King County Department of Natural Resources, the Puget Sound Clean Air Agency as well as a citizen volunteer with climate change expertise.

[2] Although not published until October 2001, these are essentially the same reporting principles contained in the "Greenhouse Gas Protocols", World Resources Institute and World Business Council for Sustainable Development.

[3] Material emissions are those of sufficient size to warrant analysis.

a precise picture of the GHG emissions that the City can directly or indirectly influence. But together, they provide a good data base from which to identify emission reduction opportunities and an encouraging account of the emission reductions already achieved and planned.

Defining the Inventories

The *City and Utilities Operations* inventory is a comprehensive inventory of the major GHG emissions associated with or directly influenced by City operations and utility operations – ranging from fuel use by motor pool vehicles in downtown Seattle to City Light purchases of energy that originate from fossil fueled power plants to gasoline used by Parks Department lawnmowers. To the extent possible, this inventory also captures those significant GHG emissions that indirectly result from City operations – for example, emissions associated with the manufacture of cement which is used in pavement, and the methane emissions associated with the production and distribution of natural gas used to heat City buildings. While emissions due to City and utility operations represent a relatively small percentage of total GHG emissions in the Seattle area, they are the emission sources over which the Mayor and Council often have more direct influence or control.

The *City Wide* inventory is different from the *City Operations* inventory in that it uses the geographic City limits to define the "boundary" of what is included (with one major exception, SeaTac Airport; see note 4b.) Most of the data in the *City Wide* inventory has been provided by the Puget Sound Clean Air Agency[3] and includes all the major greenhouse gas emissions that actually occur within the City limits including the region's major source of greenhouse gas emissions – traffic – as well as emissions associated with industry, heating all the homes and businesses in the City, etc. Because only emissions within the city limits are counted (with the noted exception) unlike the *City Operations* inventory it does not include indirect emissions (also called upstream emissions.) It does include a sub-set of the *City and Utilities Operations* inventory (those that occur within City limits.)

Which greenhouse gas emissions are inventoried?

The major human-caused greenhouse gases that contribute to global warming are carbon dioxide, methane, nitrous oxide, hydrofluorcarbons, perfluorocarbons and sulfur hexafluoride. All are included except for nitrous oxide and perfluorocarbons, because emissions of these gases are insignificant in Seattle[4]. The global warming potential (GWP) is presented in parentheses.

- *Carbon dioxide (CO2),* is released to the atmosphere when fossil fuels (oil, natural gas, and coal), and wood and wood products are burned. It is the most prevalent of all greenhouse gases, accounting for 82% of total emissions in the US. (GWP = 1)
- *Methane* is emitted during the production and transport of coal, natural gas, and oil; the process of decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock. It accounts for 10% of GHG emissions in the US. (GWP =23)
- *Hydrofluorocarbons* (HFCs) (GWP=140 to 6,300), *perfluorocarbons* (PFCs) (GWP = 6,500 to 9,200 and *sulfur hexafluoride* (SF6) (GWP = 23,900) are man-made gases used or generated by a variety of industrial activities.
- *Nitrous oxide* is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels. (GWP =296)

HFCs, PFCs and SF6 are by far the most potent of the greenhouse gases in their ability to trap atmospheric heat. To account for these different potencies, the GHG emissions for these gases have been converted to be equivalent to the weight of CO2, termed 'carbon dioxide equivalent.'

[3] In 2001, the Puget Sound Clean Air Agency decided to develop a climate protection program. As part of that initiative, they are inventorying GHG emissions within the corporate limits of King County and the City of Seattle.
[4] It isn't a factor because the type of industrial and agricultural processes that emit significant amounts of the gases, e.g., manufacturing nylon and fertilizing fields, do not occur in Seattle.

Where does carbon sequestration fit in?

The city-owned Cedar River Watershed contains roughly 85,000 forested acres. The living trees *remove* carbon dioxide from the atmosphere and store it as biomass. Commercial harvesting of timber did occur on a small scale in the watershed until 1995, and this resulted in *release* of carbon dioxide into the atmosphere from decay or burning of biomass. Recent research on sequestration and release of carbon in Pacific Northwest forests provided useful models for the estimates of these effects at the watershed which are included in the report. (See Attachment 1 for an explanation of the carbon sequestration calculations used in this report.)

FINDINGS

City and Utilities Operations

- The City has substantially reduced GHG emissions attributable to its operations and projections are that the trend will continue. The Kyoto Protocol calls for US emissions to be cut by seven percent below 1990 levels by 2012. Comparing 2000 to 1990, the City has already cut its emissions by 59 percent, primarily because it divested its interest in the Centralia Coal Plant. Other reductions are due to flaring methane at a closed City landfill and recycling programs that have reduced the emissions associated with the handling of solid waste.
- Projections are that by 2010, the City will cut its emissions by over 100 percent compared to 1990. In addition to the landfill reductions the other major reductions are due to City Light's commitment of no net GHG emissions by 2003, and the cessation of commercial harvesting at the Cedar River Watershed.
- Without the City's recycling and energy conservation programs, the City's emissions in 2000 would have been more than twice as large as they were. In 2010, more than 890,000 tonnes of emissions will be avoided due to a recycling rate of 60 percent.

Citywide

- Citywide emissions in 2000 remained essentially constant compared to 1990 but by 2010 are projected to increase by nearly 20 percent over 1990 levels.
- In 2000, transportation accounted for 56 percent of Seattle's GHG emissions compared to 31 percent for the nation as a whole. Transportation accounts for a higher percentage of our GHG emissions than the rest of the country because our region uses less coal or other GHG- emitting electric power sources.
- To fulfill the Kyoto Protocol goal of reducing emissions to seven percent below 1990 levels means that Seattle's emissions target would be 6.5 million metric tonnes[5] of CO2 equivalents (about 480,000 tonnes less than current levels.) To reach a forty percent reduction target would mean that Seattle's emissions would be 4.2 million tonnes of CO2 equivalents in 2010.
- Additional emissions were avoided through such measures as the changes to the City's energy code that require gas heated buildings to be more energy efficient and the regions' various transportation programs – transit, heavy rail, bicycle commuting and van and car pools – that increase mobility and reduce the use of single occupancy vehicles. However, data by which to estimate emissions reductions due to these measures are not available.

Overarching

- The City's achievement in reducing emissions is significant, demonstrating that substantial GHG reductions are both attainable and consistent with other financial and environmental objectives. The City's strong performance also provides an important foundation for broader emission reduction activities in the community. Continued reductions in two major sources of emissions – electricity production and solid waste management – are directly connected to City policies and programs but

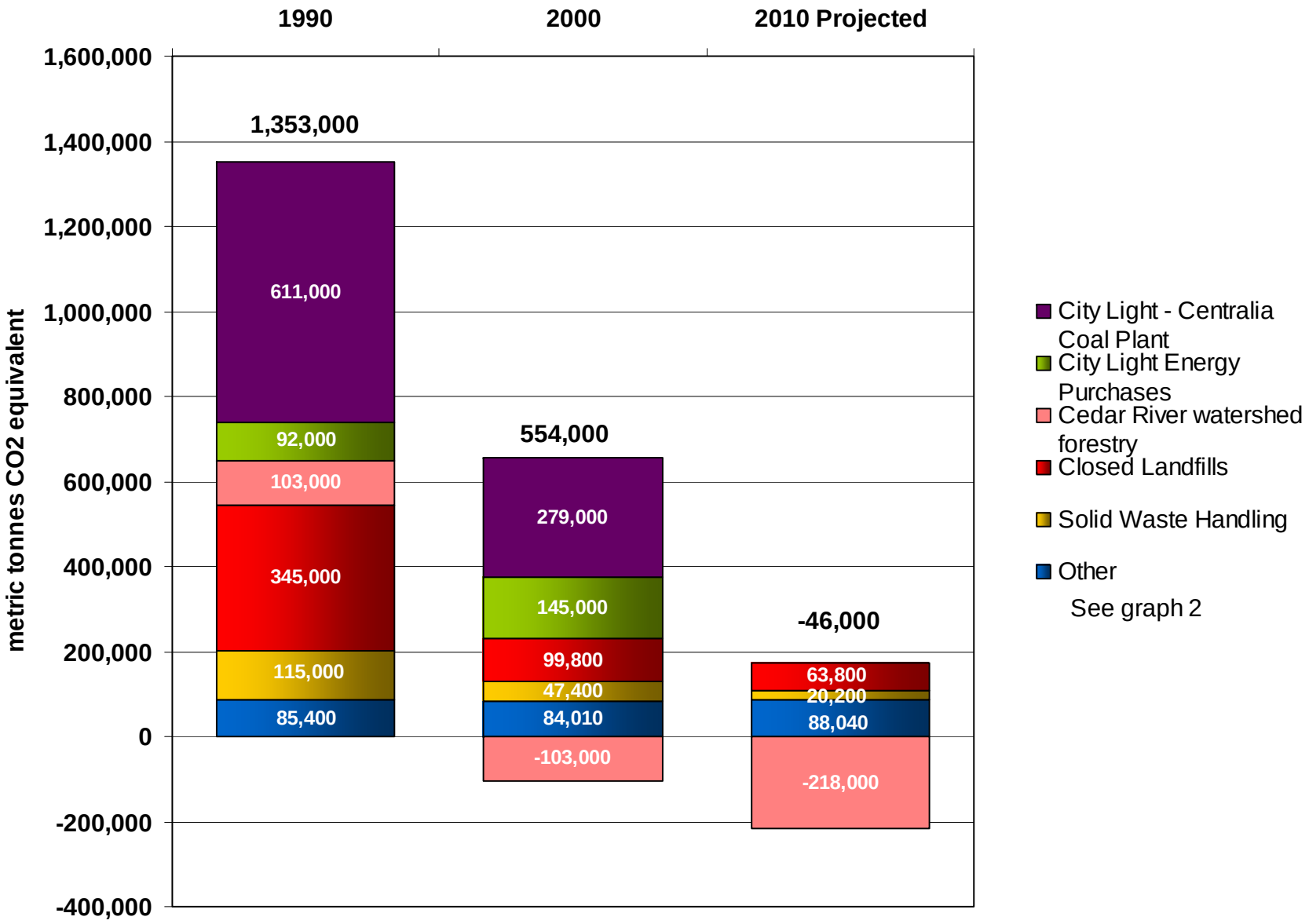
[5] Metric tonnes is the internationally accepted unit of measurement for greenhouse gases. A US short ton = .90718 metric tonnes.

the single largest source of emissions – transportation – is less direct. Achieving Resolution 30316's goal of reducing emissions by seven to forty percent will require a combined emphasis of reductions in both community wide emissions and City and Utility Operations' emissions.

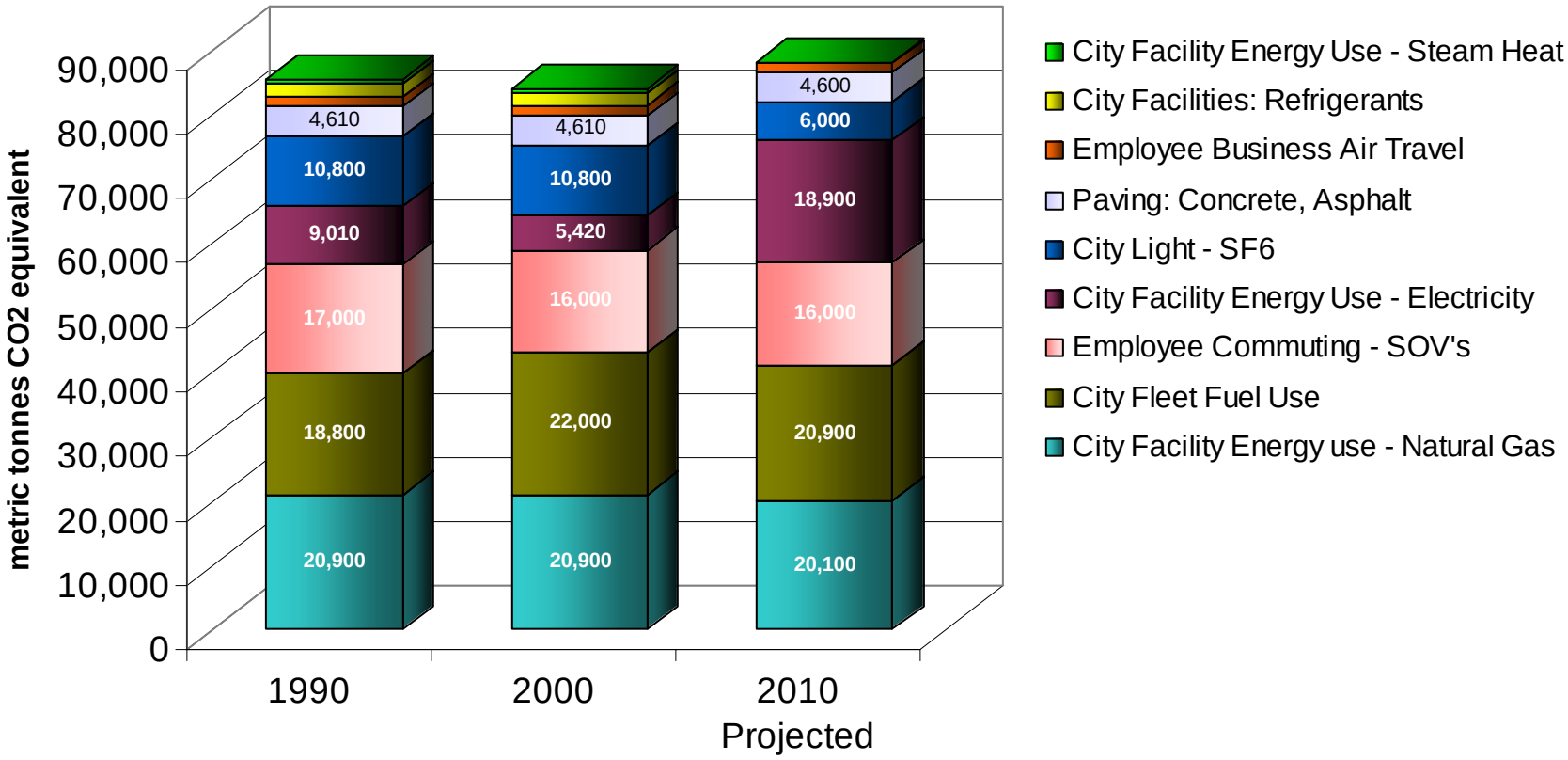
Table A: City of Seattle Greenhouse Gas Emissions Inventory - City and Utilities' Operations
(all emissions are displayed in metric tonnes and have been converted to CO2 equivalents)

SOURCE		**1990**	**2000**	*Projected for 2010*
Note #				
1a.	***City Light – Centralia Coal Plant[6]***	611,000 (45.3%)	279,000	0
2a.	***City Light energy purchases***	92,000 (6.8%)	145,000	0
3a.	***Closed landfills***	345,000 (25.6%)	99,800	63,800
4a.	***Solid waste handling***	115,000 (8.5%)	47,400	20,200
5a.	***City facility energy use – natural gas***	20,900 (1.5%)	20,900	20,100
6a.	***Fleet fuel use***	18,800 (1.4%)	22,000	20,900
7a.	***Employee commuting – SOVs***	17,000 (1.3%)	16,000	16,000
8a.	***City Light – SF6***	10,800 (0.8%)	10,800	6,000
9a.	***Paving: concrete and asphalt***	4,610 (.3%)	4,610	4,600
10a.	***City facilities: refrigerants***	2,000 (.1%)	2,000	Unknown
11a.	***Employee business air travel***	1,540 (.1%)	1,540	1,400
12a.	***City facility energy use – electricity***	9,010 (.6%)	5,420	18,900
13a.	***City facility energy use – steam heat***	740 (.1%)	740	140
14a.	***Cedar River watershed forestry***	103,000 (7.6%)	(103,000)	(211,000)
	Total	**1,353,000 tonnes**	**554,000 tonnes**	**(39,000 tonnes)**
15a.	***Emissions avoided - SPU recycling***	407,000	539,000	891,000
16a.	***Emissions avoided - SCL conservation***	88,200	278,000	Unknown
17a.	***Emissions avoided - Muni Conservation (natural gas)***		398	Unknown
Total emissions if programs that reduce emissions had not occurred		**1,850,000 tonnes**	**1,370,000 tonnes**	**852,000 tonnes**

[6] The City sold its ownership share in Centralia Coal Plant in April 2000 for environmental and economic reasons.



Graph 1: ***Major Sources of GHG Emissions from City Government and Utility Operations***



Graph 2: ***Smaller Sources of GHG Emissions from City Government and Utility Operations***

GHG Inventory: City and Utilities' Operations.
Explanations, notes, etc. for Table A.

Original source data is on file at the Office of Sustainability and Environment. Below is a summary of where the data was obtained, how it was compiled, etc.

1a. **City Light - Centralia Coal Plant** Until May of 2000, City Light owned a share in the Centralia coal plant. The combustion of coal emits large quantities of carbon dioxide, as well as other pollutants. Electricity generation in older coal plants emits approximately 60 percent more CO2 than generation from modern gas fired plants. In April 2000, the City sold its share of the Centralia Coal Plant which substantially reduced its total GHG emissions.

2a. **City Light energy purchases** Included here are emissions from:

- Net short-term market purchases (using EPA Region 10's carbon intensity factor as a proxy for how much of the purchased energy originated from fossil fuels.) Because hydro resources vary year to year, the amount of energy that must be purchased on the market also varies; thus, emissions for 2000 were computed as an average of 1998-2000 purchases. Net short-term market purchases were less than 0 in all years except 1998 making it a very small source.
- Net purchases from BPA (long-term contracts) again using EPA Region 10's carbon intensity factor.

Projected SCL emissions for 2010 are zero (excluding SF6) based upon the City's adopted commitment for City Light to meet all of Seattle's electricity needs with zero net release of greenhouse gas emissions. Note: Sulfur hexaflourlide (SF6), used in electrical substations is listed separately (see note 8a.)

3a. **Closed landfills** A number of City owned landfills that are now closed continue to produce methane. Methane has a global warming potential 21 times that of carbon dioxide on a weight-for-weight basis. The significant decline in emissions from 1990 to 2000 is because a methane collection and flaring system was installed at Kent Highlands (Note: only un-flared methane is counted. Consistent with international protocols for GHG inventories, the CO2 produced by flaring at some of the landfills is not counted; carbon is largely from biomass such as crops or forests and is therefore part of the natural carbon cycle.) Projections for 2010 decline as the landfills continue to age and the decomposition process nears completion; projections are based on engineering models and time series data from these landfills. Data for this category were supplied by Seattle Public Utilities.

4a. **Solid waste handling** – Seattle's solid waste is managed by Seattle Public Utilities. The emissions in this category have been calculated by modeling (using the EPA WARM_02 model) the lifecycle of solid waste handled by SPU in 1990 and 2000 that has been transported and landfilled at Cedar Hills (1990) and Arlington, Oregon (2000.) Emissions are due to fossil fuels used by trains and trucks transporting the waste, and to methane produced by decomposition. The projected amount of emissions in 2010 from these sources also comes from the Warm_02 model from EPA, and is considerably smaller than the 2000 figure due to a 60% recycling target by 2010. This number is then increased by 1% per year to allow for Seattle population growth between 2000 and 2010. An 85% methane capture rate at the landfill is assumed.

5a. **City facility energy use – natural gas** The City owns and operates hundreds of buildings, many of which use natural gas for heating and hot water. Emissions were calculated by reviewing gas billing records provided by the various City departments; in some cases the records stated the cost of the gas, and in some cases the records stated the actual number of therms. Using industry accepted assumptions,

upstream leakage of natural gas during production and transmission was included in the emissions calculations. Because data was not available for 1990, the data for 2000 was used as a proxy. The 2000 figure was the starting point used to estimate the emissions from this source in 2010, Estimates of natural gas reductions due to planned capital projects at Parks and ESD reduced this number by 800 Metric tonnes.

6a. **Fleet fuel use** This includes all emissions associated with burning diesel, gasoline, compressed natural gas (CNG), propane and biodiesel to operate the City's extensive fleet of construction equipment, trucks, vans, cars, and other vehicles (e.g., meter reading scooters) as well as mowing machines, leaf blowers, etc. The data were provided by Fleets and Facilities Department which maintains records of fuel use by each department, and by remote City Light operations. Since data were not available for 1990, 1995 data was used for that year. Current proposals are to reduce fleet fuel use by 1% per year over five years (2001 to 2005), Therefore, projections for 2010 are assumed to equal : **[Year 2000 vehicle fleet emissions] times $(0.99)^5$. The result is [22,000 Metric Tonnes CO2 / year] * 0.951, or 20,900 Metric Tonnes CO2.** Note: Data were not available on fuel used by employees driving their personal vehicles for City business so emissions in this category are understated.

7a. **Employee commuting - SOVs** Employees who drive by themselves to and from work add emissions; some of these trips are by personal choice but in many cases an employee doesn't have a choice because of his or her job location, e.g., it isn't on a convenient bus route. The estimated emissions for this category are based on 2000 survey data collected by the City's Commute Trip Reduction Program (CTRP) and extrapolated to include employees not part of the survey, i.e., job sites not in the downtown core, swing and night shift employees, etc. The 2000 value was also used for the 2010 projection.

8a. **City Light – SF6** Sulfur hexafluoride (SF6) is used in City Light's electrical switchgear as a coolant and fire suppressant; it is one of the most potent global warming gases there is - *one pound of SF6 has the same global warming* potential *as approximately 10,800 lbs of CO2.* The figures for annual leakage of SF6 from City Light equipment in 2000 are approximate (1,000 pounds). A working group at SCL is improving these estimates and reducing the annual leakage. There are new technologies that reduce the amount of SF6 required in switchgear. For these reasons, the projected leakage of SF6 in 2010 has been reduced compared to the amount estimated for 2000.

9a. **Paving: concrete and asphalt** There are significant CO2 emissions associated with the manufacture of cement for concrete. The same is true of the production of bitumen for asphalt. In 2000, the City paved 3.8 lane miles of concrete, 25.7 lane miles of asphalt and used 66,000 tons of asphalt to fill potholes. Data on the volume of both concrete and asphalt used for paving during 2000 were provided by Seattle Transportation. The numbers used in these calculations came from current research on the lifecycle emissions for these products. The total emissions figure for 2000 was used for both 1990 and 2010 due to the lack of data for those years. There is a good possibility that CO2 emissions from concrete paving will be smaller in 2010, due to reduced use of cement per ton of concrete poured. Neither the amount of concrete to be used in 2010, nor the reduction in cement per ton of concrete is certain at this time.

10a. **City facilities: refrigerants (PFC and HFCs)** Refrigerants – gases- are used in building mechanical systems to cool buildings and have very high global warming potential. The 2000 figure for CO2 equivalent emissions is based on discussions with engineers in the largest city buildings, and on data for system leakage in the Public Safety and Municipal buildings and fire and police stations. Lacking comprehensive data for city operations, this estimate could understate total emissions in this category. Given the lack of data and the fact that in 2010 the Municipal and Public Safety buildings will no longer exist, no estimate is presented for refrigerants for 2010.

11a. **Employee business air travel** In 2000, according to data provided by the Finance Department, employees traveled at least 4.5 million miles on City business on commercial air liners. A figure of 0.34 kiloGrams per passenger air mile was used to calculate the total emissions, based on several current

reports. The 2010 estimate was reduced by 10% to reflect continuing improvements in airplane efficiency over the next decade.

12.a **City facility energy use – electricity** This figure was arrived at by first calculating the emissions of CO2 per mWh sold by City Light then multiplying that by the total amount of electricity used in city operations and utilities for the year. The City electricity use for 2000 was provided by City Light staff. (Note: emissions associated with electricity use in City facilities has been subtracted from the total City Light emissions so this figure does not double-count City Light emissions.) However, emissions in this category are understated for two reasons: one, City Light data on electricity use in City operations do not include street lamps, traffic signals and some City Light facilities; and, two, data were not available for electricity use by City facilities outside City Limits, e.g., pump stations located in Puget Sound Energy service territory. The projected increase in 2010 in this category is due to the planned Cedar River water treatment plant which will be served by Puget Sound Energy; emissions were calculated assuming the new electric load is 5.5 mW which is met by an efficient combined cycle natural gas combustion turbine.

13a. **City facility energy use – steam heat** Steam heat (produced by natural gas) is purchased to heat several downtown City office buildings. Emissions were calculated using billing data from Seattle Steam. Projected emissions for 2010 were reduced to reflect the fact that in 2010 only the Arctic Building will be using steam heat.

14a. **Cedar River Watershed Forestry** The 85,000 acres of forest sequesters carbon in large amounts.. Recent research on carbon storage in Northwest forests and on carbon release due to commercial harvesting provides models for estimating these effects at the watershed (See Attachment 2.) Large scale commercial harvests ended in the mid-1990's and a permanent ban on logging was legislated by Seattle's Mayor and Council in 2000. Ecological thinning to encourage old-growth forest will begin in 2003 and will account for very small amounts of carbon release; carbon sequestration will become dominant by 2010. (See Attachment 1 for more information.)

Emissions Avoided

15a. **SPU recycling -** The majority of avoided emissions due to solid waste recycling occurs as a result of recycled material displacing the need to manufacture new product, thereby avoiding the use of fossil fuel energy used in manufacturing. Other emissions are avoided because less solid waste is transported and landfilled. Seattle Public Utilities used the US EPA waste reduction model, WARM, to generate the data, assuming the approximate 300,000 tons of material that was recycled in Seattle in 2000. The recycling goal for year 2010 has increased to 60%, so the avoided emissions due to recycling are considerably larger than those estimated for 2000.

16a. **Electricity conservation –** The calculations are based upon Seattle City Light's conservation program savings of 224,800 MWh in 1990 and 708,500MWh in 2000. These energy savings meant that City Light avoided purchasing a like amount of energy that would have been generated by an energy efficient combined-cycle natural gas turbine. It is difficult at this time to estimate the emissions reductions due to electricity conservation programs at City Light in 2010.

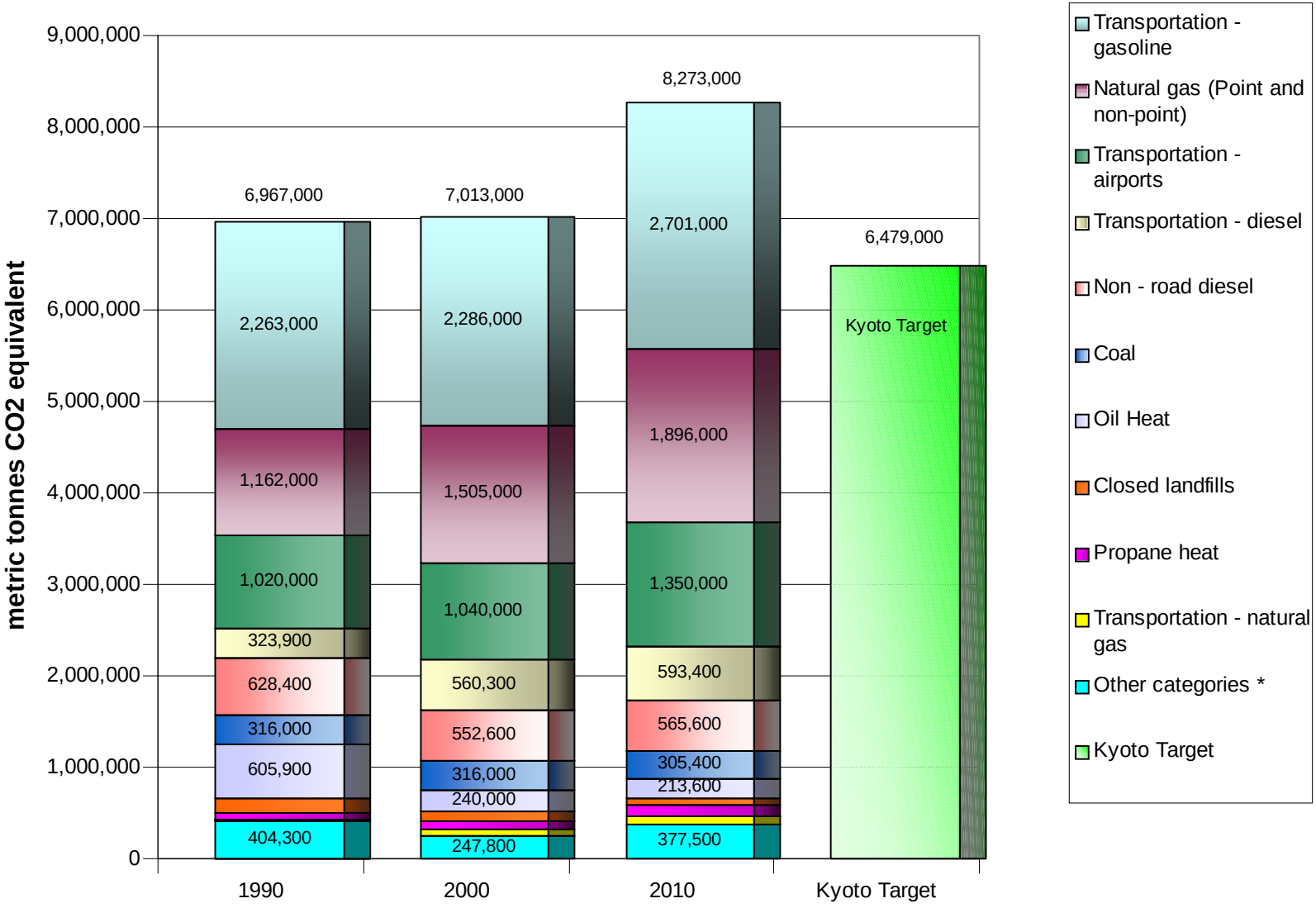
17a. **Conservation savings – natural gas** – Through the City's Municipal Conservation Program, several City facilities retrofitted their facilities to be more energy efficient thereby reducing energy use.

Table B: City of Seattle Greenhouse Gas Emissions Inventory - Citywide

(All emissions are displayed in metric tonnes and have been converted to CO2 equivalents; data is primarily courtesy of the Puget Sound Clean Air Agency.)

1b. Source	1990		2000		2010	
2b. Transportation – gasoline	2,263,000	32.5%	2,286,000	32.6%	2,701,000	32.6%
3b. Natural gas (Point and non-point)	1,162,000	16.7%	1,505,000	21.5%	1,896,000	22.9%
4b. Transportation - airports	1,020,000	14.6%	1,040,000	14.8%	1,350,000	16.3%
5b. Transportation - diesel	323,900	4.6%	560,300	8.0%	593,400	7.2%
6b. Non - road diesel	628,400	9.0%	552,600	7.9%	565,600	6.8%
7b. Coal	316,000	4.5%	316,000	4.5%	305,400	3.7%
8b. Oil Heat	605,900	8.7%	240,000	3.4%	213,600	2.6%
9b. Closed landfills	152,500	2.2%	99,800	1.4%	63,800	0.8%
10b. Propane heat	66,910	1.0%	105,000	1.5%	129,900	1.6%
11b. Transportation – natural gas	24,060	0.3%	60,520	0.9%	76,830	0.9%
12b. Other categories *	404,300	5.3%	247,800	3.5%	377,500	4.6%
Total	6,967,000	100.0%	7,013,000	100.0%	8,273,000	100.0%

* Other includes: Non road gasoline, distillate oil combustion, LPG combustion, fireplaces, point-source residual oil & point-source tires.



Graph 3: *GHG Emissions by Source for Seattle* (All emissions within City limits and a proportionate percentage of the SeaTac and King County airports. Data primarily courtesy of the Puget Sound Clean Air Agency.)

The Kyoto Protocol sets the US target for reducing greenhouse gas emissions at 7% below 1990 levels. For Seattle, that target would be 6,479,310 metric tonnes.

GHG Inventory: Citywide.
Explanations, notes, etc. for Table B.

Original source data is on file at the Office of Sustainability and Environment. Below is a summary of where the data was obtained, how it was compiled, etc.

1b. **Transportation - gasoline**. Each day, hundreds of thousands of cars, trucks, motorcycles, etc travel on Seattle's roads and highways which result in the largest single source of GHG emissions in Seattle (also included in this category is off-road use of gasoline such as for lawnmowers, leafblowers, etc.) The emissions were calculated by the Clean Air Agency by apportioning Seattle's population to total gasoline sales (provided by the Washington State Department of Transportation) for 1990, in King County, and for 1999, for the state. Although the data show only a nominal increase in gasoline emissions within the City, it's important to note that the Clean Air Agency's data do indicate a significant increase in the region: between 1990 and 2000, emissions went up by seven percent in the County (including Seattle) and in the four county region by 16 percent. The pounds of CO2 per thousand gallons of gasoline is based on EPA published standards (AP-42.)

2b. **Natural gas** (Point sources and non-point sources). Natural gas is used to heat homes and businesses (non-point) and for a number of manufacturing and industrial processes (point.) Point source gas data comes from the Clean Air Agency; small combustion sources data come from local companies' figures for annual natural gas sales to households, and census data about the number of households using natural gas in Seattle.

3b. **Transportation – SeaTac and King County Airport** The airline industry has, over the past 30 years, improved fuel economy per passenger mile by 61 percent. Growth in air travel, however, has resulted in energy use by commercial aircraft nearly doubling in the same period[7] - which accounts for this category being the third largest source of GHG emissions. Emissions in this category were based on fuel sales data from the two airports (reported to the Clean Air Agency annually) and assigning a percentage of those sales to Seattle business and residents (Port of Seattle data indicate that 29% of passengers are from Seattle.) Emissions of CO2 from jet fuel and aviation gasoline were computed using IPCC methods.

4b. **Transportation/Construction – diesel** Diesel is used to fuel buses, trucks, trains, some passenger vehicles and a variety of heavy duty construction equipment, e.g., backhoes, road graders, etc. The data was supplied by the Clean Air Agency using the same calculations as described in note 1.

5b. **Coal from point sources.** Coal is still used by a few Seattle industries. The data was supplied by the Clean Air Agency. Coal combustion produces primarily CO2. The CO2 emissions were calculated using EPA standards (AP-42.)

6b. **Oil heat**. Homes are the largest users of oil heat. The ratio of oil heated homes in Seattle to oil heated homes statewide was applied to statewide oil sales as the basis for total oil use. The emissions factor for this source of CO2 comes from EPA standards (AP-42). Data was supplied by the Clean Air Agency.

7b. **Diesel – off-road**. This category includes one large source - shipping activity within Puget Sound --and three smaller sources: trains, ferries and construction equipment. (IPCC standards exclude international shipping in calculating GHG emissions.) *The USGH-98 standard was used to calculate CO2 emissions.* The shipping data used the distance traveled within the sound, and an average consumption rate of 140 gallons per hour.

8b. **Closed landfills** This data consists of estimated emissions from several closed landfills within City limits – Interbay, Judkins Park, South Park, West Seattle and Montlake (those that have been closed for

[7] Rocky Mountain Institute, Colorado.

more than 30 years were not inventoried because they are generally not emitting any longer, that is, the decomposition process is complete.) Methane, which is 21 times more potent than CO2, is the gas at issue for this source. CO2 emissions from landfills are not counted because they come largely from biomass and reflect recycled carbon activity. The methane emissions data were reported by the Seattle Public Utilities Department, and by the Clean Air Agency. Emissions estimates are based upon estimated land-filled volume, or upon site-specific data emissions. Because complete emissions data were not available for Montlake and West Seattle, landfills that were privately owned, emissions in this category are somewhat understated.

9b. **Propane heat**. Statewide data on propane sales were scaled to Seattle using the ratio of Seattle households using propane to statewide households. The emissions factor for this source of CO2 comes from the EPA's AP-42 standards.

10b. **Transportation – natural gas** There is a growing number of compressed natural gas powered vehicles in use, primarily because it is a cleaner burning fuel. Data was supplied by the Clean Air Agency.

11b. **Other -** Non-road gasoline, distillate oil combustion, LPG combustion, fireplaces, point-source residential and point source tires.

Attachment 1

CARBON DIOXIDE EMISSIONS AT THE CEDAR RIVER WATERSHED: THE EFFECT OF THE LOGGING BAN

Office of Sustainability and Environment 2002

Introduction

The City of Seattle Report and Inventory of Greenhouse Gas Emissions (April, 2002) includes many sources of the greenhouse gas carbon dioxide (CO2) emitted as a result of City and utility operations. The inventory, however, did not address CO2 emissions or sequestration associated with the 90,000 forested acres in the Cedar River Watershed, which is owned by the City. This paper summarizes the results of an analysis of the net effects of the watershed trees on the City of Seattle's CO2 emissions. The approach of this analysis is consistent with the completed GHG inventory in that it compares the baseline year of 1990 emissions to 2000 and projects them forward to 2010. It takes into account the major change that has occurred in the watershed during that time – a ban on logging.

Background

All living plants, including trees, grow by absorbing carbon dioxide from the atmosphere through photosynthesis – in effect a growing forest works as a "carbon sink." When trees or parts of trees die and decompose or burn, they release this carbon back into the atmosphere as carbon dioxide. Under normal equilibrium conditions, the carbon absorbed by living trees is balanced by that released from decomposition and burning. Logging interrupts this cycle: manufactured wood products release CO2 over many decades while waste wood, paper and hog fuel decay in less than a decade. On average one-third of logged trees becomes structural wood which is assumed to decay at a rate of 2% per year over 50 years. Another third decays over a period of only 5 years. The remaining on-site debris decays at a decreasing rate over several decades in an exponential manner.

CO2 emissions that occur as part of the decay of man-made products are not counted in inventories of greenhouse gas emissions as long as they are part of a continuing cycle, according to international protocols. However, banning logging has changed the cycle at the watershed, since carbon is no longer harvested.

The balance of CO2 releases and CO2 storage in a forest determines the long-term average NET carbon storage. Faster logging rotation decreases the long-term NET carbon storage, because the trees never achieve the mass of older trees. Until 2000, the City of Seattle allowed limited commercial logging in the Cedar River Watershed's 85,000 forested acres. The rotation period appears to have been something slightly more than one hundred years. In 2000, logging was banned.

When the City's inventory of its greenhouse gas emissions was conducted in late 2001, CO2 emissions and storage from the Cedar River Watershed were not included because of a lack of time to conduct the analysis. This analysis has now been completed and calculates the emissions and storage capacity of the forest in 1990, 2000 and 2010. Since logging was banned in 2000, the particular challenge is to calculate the impact of that change.

Beginning in 2003, forest thinning is planned in the Watershed to encourage the development of the old growth forest. Removed wood will be processed for commercial uses; using the same analytical approach as used for the remainder of this analysis, the estimated CO2 release is a range of 5,230 tonnes to 14,600 tonnes. In order to incorporate a single number the average, 9,915 tonnes, is used here.

Results and Analysis

The effect of the logging ban is that by allowing trees to attain great age and size, a great deal of CO2 is stored: by 2010, the watershed will sequester a net 211,000 metric tones of CO2/year. By the year 2040, the carbon emissions from decay of structural wood products will no longer affect the annual picture, and carbon storage will be the only component of CO2 change.
.
The first restrictions on logging at the CRW occurred in the late 1980's, and the final ban took place in 2000. Therefore, CO2 release began to drop by the year 2000 because decreased logging means decreased short-term decay of logged wood. By 2010, the impact of the logging ban on carbon release will be much greater because longer term decay of structural products will have been reduced further, and because the decay of on-site debris from logging will be largely complete. Storage of CO2 into new biomass will still be increasing at that time and will become the dominant component. A summary of results is given in the following table and chart.

Assumptions

1. Calculations are based upon estimated acres of forest logged each decade from 1900 on, and upon the board feet logged each decade. The year 2000 report: “Final Cedar River Watershed Habitat Plan” provides this information, but in blocks of years that do not correspond to decades. Data were prorated to fit into the decade periods.

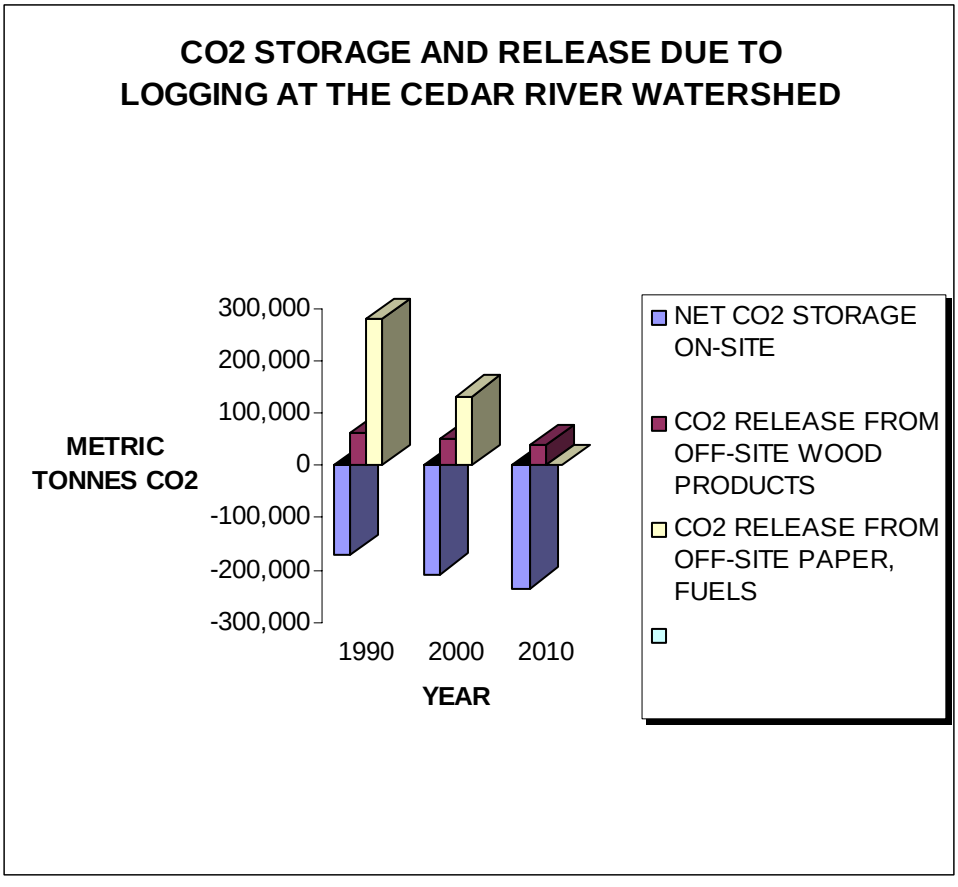
2. Information from “Modeling Carbon Stores in Oregon and Washington Forest Products”, by M. E. Harmon, 1996 provides estimates of tones of carbon per million board feet of wood in Douglas Fir forest products.

3. Estimates of the fraction of harvested wood which becomes relatively long-lived structural wood, and the fraction which becomes short-lived paper and fuels came from “Forest Carbon in the United States: Opportunities and Options for Private Lands” by L. A. Wayburn *et al.*, 2000.

4. A model for estimating the net carbon storage and release from on-site forests after logging came from “Successional Changes in Live and Dead Wood Carbon Stores: Implications for Net Ecosystem Productivity” by J.E Janisch and M.E. Harmon in 2002. Scenario 3, the old growth forest with remaining logging debris, was selected. Average parameter values were used to calculate results.

CARBON DIOXIDE RELEASE AND STORAGE AT THE CEDAR RIVER WATERSHED
1990, 2000 AND 2010 (measured in metric tonnes)
Parentheses indicate storage; no parentheses indicate release

YEAR	SINK AND SOURCE ON - SITE	SOURCE OFF-SITE STRUCTURAL	SOURCE OFF-SITE PAPER, FUEL	**TOTALS**
1990	(234,206)	58,106	279,514	103,414
2000	(285,080)	49,943	132,594	(102,543)
2010	(259,799)	39,296	9,915	(210,588)



Attachment 2

Supporting Data and Notes for the Cedar River Watershed Sequestration Analysis
Tim Newcomb, December 2002

Three additional studies of carbon sequestration in forests of western Washington and Oregon are briefly reviewed below, in order to get an idea of the range of sequestration rates for forests like the Cedar River Watershed CRW). These studies were chosen to include a variety of authors and methodologies.

Study one: "Two Decades of Carbon Flux from Forests of the Pacific Northwest", Cohen et al., 1996, Biosciences # 46, **11.**

This study has a very large scale, covering 10.4 million acres of west slope forest in Oregon and Washington. One part of this study addresses sequestration rates for 80-year-old second-growth conifer forests. Extensive satellite data were complimented by data from selected sites. Live biomass, detritus and forest products were included. The data were analyzed using the Chapman-Richards statistical function. The estimate for sequestration for 80-year old forests was 374,000 tonnes of CO2 per year in an area the size of the CRW.

Study two: "Campbell River, British Columbia: An Ameriflux Site", Black et al., 2002, on web at : www.agsci.ubc.ca/biomet/campbell.htm.

This study is from a very small site on Vancouver Island near Courtenay. The stand is composed of 50 year-old second growth, 80% Fir and 20% cedar. The authors used sensors to measure the amount and flow of CO2, latent heat, sensible heat, solar radiation, and wind speed. The data were calibrated and evaluated on an overall energy balance approach. The study included 10 months, excluding late June to late August. It reports continuous photosynthesis through the winter months. When the ten-month period is corrected on a pro-rata basis to twelve months, the estimated sequestration is 393,000 Tonnes CO2 per year for an area the size of the CRW. Equipment calibration and the representativeness of the site are possible study weaknesses.

Study three: "Use of a Physiologic Process Model with Forestry Yield Tables to set limits on the Annual Carbon Balances", Waringe and McDonnell, 2002, Tree Physiology, **22.**

Douglas fir second-growth forests at Wind River, Washington included 70 year-old trees. The maximum NEP estimated from yield data and weather data were computed. This is the most superficial study with apparently very little on-site original data. The resulting computation is a maximum of 371,000 tonnes CO2 per year for an area the size of the CRW.

Discussion: The high degree of agreement is misleading in so far as the third study presented an estimate of maximum sequestration. The agreement is satisfying in that several different approaches are in the same small ballpark. These estimates are all approximately 35% above the calculation for the CRW in the inventory, but again, study three produced a maximum amount not an average amount. So the CRW estimate does not appear to be too large, and is if anything, an underestimate. It is worth noting that the study used for the on-site sequestration estimate in the inventory used still another method for arriving at its estimate. The amount of sequestration in western Oregon and Washington forests is apparently determinable by a variety of routes.

Attachment C

Emissions Inventory Recommendations

January 9, 2006

TO: Green Ribbon Commission Members

FROM: GRC Metrics Sub-Group: Denis Hayes, Doug Walker, Dennis McLerran

CC: Steve Nicholas, Kim Drury

RE: Recommendation Regarding the Kyoto Target

At the December 13 Green Ribbon Commission (GRC) meeting, staff informed the Commission that it had new data regarding transportation energy use—gasoline and diesel— as well as new natural gas data. The new data are more current and Seattle specific, allowing for a more accurate inventory of emissions for both 1990 and our target date of 2012. Steve Nicholas mentioned that the new data could affect the size of our Kyoto target, i.e., the number of projected tons of GHG emissions Seattle will need to cut by 2012.

The GRC unanimously agreed that the inventory data needs to be as accurate as possible and asked the Metrics Subgroup to review the data and make a recommendation on how to proceed to the GRC. We met late last month with staff to go over the data, methodology and to discuss implications for our GHG emissions projections and reduction target. **Our conclusion and recommendation is to incorporate the updated data. It is both more current and more accurate. The primary implication is that our Kyoto target is to reduce GHG emissions by 683,500 tons by 2012 instead of the previous estimate of 1,010,600 tons.**[8]

Discussion:
The improved natural gas data are straightforward, consisting of numbers obtained from Puget Sound Energy that are specific to Seattle. Accordingly, the inventory has been revised to reflect the new data.

However, translating the new transportation data into GHG emissions estimates requires making assumptions and using models that make the analysis somewhat subjective. [9]

Initially, the GRC relied upon a greenhouse gas inventory completed by city staff in 2002. This inventory was based primarily on data compiled by the Clean Air Agency in 2000. To calculate on-road transportation emissions (from gasoline and diesel fuel) the Agency used regional vehicle

[8] The Kyoto target date is to cut GHG emissions by 7% by 2012. However, throughout this paper, you'll see data in terms of 2010. Because our initial GHG inventory target year was 2010, we've remained consistent by using 2010 data in the inventory and analysis. Given that 2010 projections are only two years shy of the 2012 target date, and the approximate nature of a GHG inventory, we believe that emissions projections for Seattle in 2010 and 2012 are essentially the same and the final report will not distinguish between the two years.

[9] Like Seattle, most community-wide emissions inventories use vehicle miles traveled data (VMT); ICLEI advises the same. We did discuss using fuel sales to measure vehicle emissions but that creates a different set of problems. For example, data is available only on a statewide basis. We could apportion the statewide data to Seattle according to population but that assumes that rural drivers and urban drivers have the same driving habits and overlooks the transit options that are available to Seattleites.

miles traveled (VMT) data obtained primarily from Department of Transportation traffic flow meters.

The Agency then (1) apportioned Seattle's share of the regional miles traveled based on population, and (2) estimated the average miles per gallon (mpg) for light duty (gasoline) and heavy duty (diesel) vehicles. It assumed that the Seattle fleet mirrored the national fleet in 1990. In order to project business-as-usual transportation emissions for 2010, the Agency made reasonable assumptions about the likely make-up of the fleet at that time and the VMT.

Those numbers, which the GRC staff have been using to date in its calculations, are summarized in the following chart:

Initial Inventory of GHG emissions CO2e (metric tons)

	1990	**2012**	**Kyoto Target**	**Reduction needed**
Gasoline	**2,263,000**	**2,701,000**		
On-road diesel	**323,900**	**593,400**		
Natural gas	891,100	1,190,600		
City Light	569,400	200,000		
Airports	1,020,000	1,350,000		
All Other	2,198,100	1,732,600		
Total	7,265,500	7,767,600	6,756,969	1,010,609

Recently, the Puget Sound Regional Council provided us with VMT data that is both more current and more accurate than was available to the Clean Air Agency when it did its emissions analysis in 2000. The new data is based on actual on-road measurements inside the city and was produced in 2005 so it gives us a much higher level of confidence in its accuracy.

However, the VMT data doesn't tell us which of those miles are driven by diesel vehicles and which are driven by light duty gasoline vehicles -- an important distinction because diesel emits about 15% more CO2 per gallon than gasoline. So, converting VMT into greenhouse gas emissions involves making informed estimates of the inventory of all the vehicles in use in Seattle and their average fuel efficiency.

To translate the VMT into CO2 emissions in 1990 and 2010, we made the following assumptions:

- For 1990 gasoline emissions: DOE's Transportation Energy Data Book lists the average on road passenger car fuel efficiency at 20.2 mpg. However, in 1990 approximately 25% of the light duty fleet consisted of minivans, light trucks or SUVs – and their average fuel efficiency was 16 mpg. Thus, the average fuel efficiency for gasoline VMTs in 1990 is estimated at 19 mpg.
- For 1990 on-road diesel: 6.5 mpg was assumed for heavy duty diesel trucks and buses in Seattle. DOE's Transportation Energy Data Book lists the average for medium and heavy duty trucks as 6.45 mpg in 1992.
- For 2010 gasoline: The average fuel efficiency of all the light duty vehicles on the road in 2010 is assumed to be 21 mpg—only a 10% improvement over 1990. We agreed on this assumption because:
    - There hasn't been any improvement in the federal fleet fuel economy (CAFÉ) standards for many years. The new state Clean Car Standards will not take effect until 2009 and are then phased in only gradually.

- In 2002 (the most recent year data is available) the fuel efficiency of the average passenger car on the road was 22.2 mpg. More than 50% of gasoline vehicles were light duty trucks, minivans and SUVs vehicles and their average fuel efficiency was 20.5 mpg.
- Consumers in our region replace their cars less frequently than the national average, so it will be impossible to achieve dramatic changes in fleet mpg by 2012.

- For 2010 diesel: The average fuel efficiency is assumed to increase to 7.5 mpg, about a 15% increase over 1990. According to the same Transportation Energy Data Book, the average improvement in fuel economy for heavy trucks in just ten years (1992 through 2002) was 13%, and that was in a period of relatively stable fuel prices. However, according to engineers at the Clean Air Agency, most of this improvement comes from the trucking industry phasing out gasoline engines during the 90's and converting to more fuel efficient diesel engines. Since that fleet turn over is pretty much complete, the rate of improved fuel efficiency is likely to be much slower over the next several years.

The one final piece of information we incorporated in the new analysis was that the Washington State Department of Transportation is projecting a significant increase in diesel use. In 1990, 14% of all fuel use in the state was diesel, but in 2010, it's projected to grow to 23% of total fuel use.

Applying the new data and assumptions yields the following results:

Recommended, updated inventory: GHG emissions CO2e (metric tons)

	1990	**2010**	**Kyoto Target**	**Reduction needed**
Gasoline	**1,348,600**	**1,535,800**		
On road diesel	**288,800**	**548,400**		
Natural gas	891,100	1,190,600		
City Light	569,400	200,000		
Airports	1,020,000	1,350,000		
All Other	2,198,100	1,732,600		
Total	6,316,000	6,557,400	5,873,900	**683,500**

Conclusion: The revised inventory presents a more accurate picture of Seattle's emissions and thus makes our analysis stronger. We conclude that the greenhouse gas inventory being used by the GRC should be revised to incorporate the new natural gas data and the updated transportation data.